Equation (10) of the Large and Yeager (2004) technical note

In theory, as well as within the Large and Yeager (2004) report, equation (10b) and (10c) write:

$$C_H = C_H^N \sqrt{\frac{C_D}{C_D^N}} \left[1 + \frac{C_H^N}{\kappa \sqrt{C_D^N}} \ln\left(\frac{z_u}{10}\right) - \psi_h\left(\frac{z_u}{L}\right) \right]^{-1} \tag{1}$$

$$C_E = C_E^N \sqrt{\frac{C_D}{C_D^N}} \left[1 + \frac{C_E^N}{\kappa \sqrt{C_D^N}} \ln\left(\frac{z_u}{10}\right) - \psi_h\left(\frac{z_u}{L}\right) \right]^{-1}$$

In both versions of 'ncar_ocean_fluxes.2004_09_02.f90', the source code available on the CORE website [1], these equations are coded the following way (lines 78 and 79):

$$C_H = C_H^N \left[1 + \frac{C_H^N}{\kappa \sqrt{C_D^N}} \left[\ln\left(\frac{z_u}{10}\right) - \psi_h\left(\frac{z_u}{L}\right) \right] \right]^{-2} \tag{2}$$

$$C_E = C_E^N \left[1 + \frac{C_E^N}{\kappa \sqrt{C_D^N}} \left[\ln\left(\frac{z_u}{10}\right) - \psi_h\left(\frac{z_u}{L}\right) \right] \right]^{-2}$$

While tested with a given atmospheric dataset (ERA-40) and a prescribed SST field (Hurrell 2003), the difference on the net heat flux is not negligible, as shown on the figure below. Using equation (2) leads to an underestimation of the net heat flux of a few W/m^2 when compared to using equation (1).
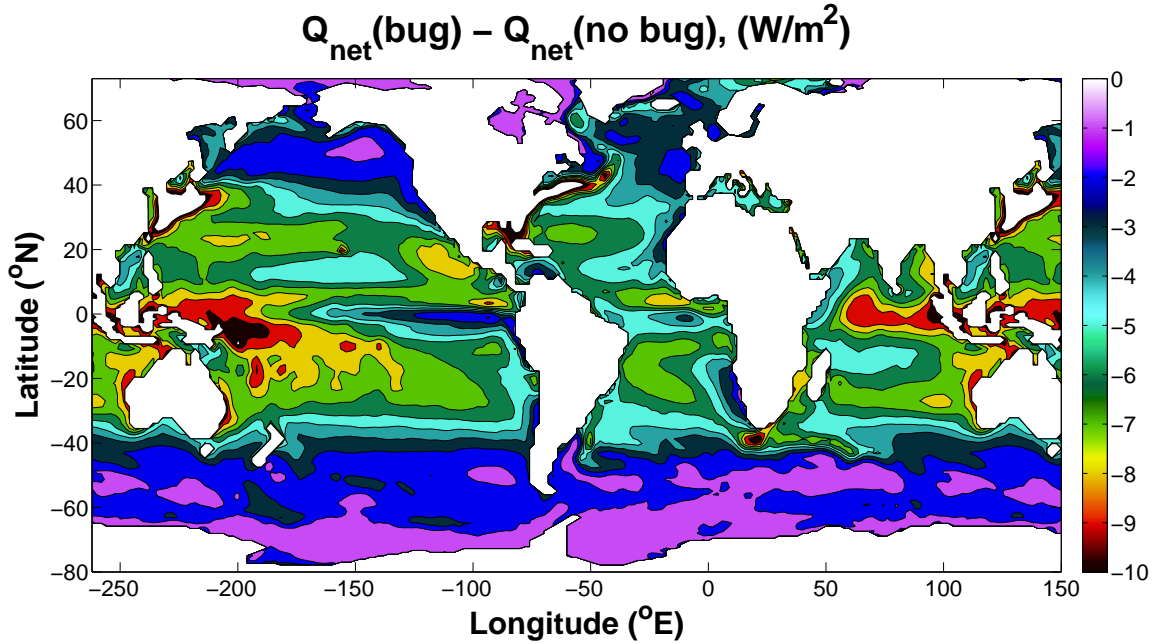

Figure 1: Error on the mean net heat flux (1984-2000) induced by the use of equation (2) instead of equation (1) for the estimation of the heat transfer coefficients. Both flux calculation are using ERA-40 variables and a prescribed SST (Hurrell 2003).

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[1] *http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE/code.html*